PATENT **DOCKET NO.: 2855/96**

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICANTS	:	Zhu FENG et al.
SERIAL NO.	:	10/618,145
FILED	:	July 11, 2003
FOR	:	A METHOD FOR ADJUSTING FLYING HEIGHT OF MAGNETIC HEADS USING AN ELECTRICAL CHARGE THROUGH AN ELECTRICAL PAD ON THE SLIDER
GROUP ART UNIT	:	2651
EXAMINER	:	James Lee HABERMEHL

M/S: AMENDMENT
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Certificate of Mailing

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail in an envelope addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on

Date: June 7, 2005 Signature: Barbara Vance

Barbara Vance

DECLARATION UNDER 37 C.F.R. §1.131

Dear Sir:

We, the undersigned, hereby declare as follows:

We are co-inventors of "A METHOD FOR ADJUSTING FLYING HEIGHT OF MAGNETIC HEADS USING AN ELECTRICAL CHARGE THROUGH AN ELECTRICAL PAD ON THE SLIDER", which is described and claimed in U.S. Application Serial No. 10/618,145 filed on July 11, 2003.

We understand that Rao et al.'s reference entitled "ELECTROSTATIC ACTUATOR WITH MULTILAYER ELECTRODE STACK" has been applied as a reference against our

patent application, and that the effective date of this reference is May 19, 2003.

We conceived "A METHOD FOR ADJUSTING FLYING HEIGHT OF MAGNETIC HEADS USING AN ELECTRICAL CHARGE THROUGH AN ELECTRICAL PAD ON THE SLIDER" claimed in our patent application prior to May 19, 2003. Reference is made to Exhibit A, dated prior to May 19, 2003, which is an invention disclosure form submitted for approval for filing a patent application.

We were diligent in reducing to practice "A METHOD FOR ADJUSTING FLYING HEIGHT OF MAGNETIC HEADS USING AN ELECTRICAL CHARGE THROUGH AN ELECTRICAL PAD ON THE SLIDER" as claimed in our patent application. Prior to May 19, 2003, our patent attorney had started work on the patent application. In addition, our patent attorney was diligent in preparing and filing the patent application on July 11, 2003.

We hereby further declare that all statements made herein of our own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Dated: 5-23-05

Zhu FENG

Dated: 5-23-05

Ellis T. CHA

Dated: 5-27-05

David HU

Dated: 5/23/05

Yen FU

2855/76

Magnetics *CONFIDENTIAL*

INVENTION PROPOSAL

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3. David Hu	REDACTED	4. Yen Fu	REDACTED

Descriptive title of proposal:
A method for lowering flying height of magnetic head at low operating temperatures

Has invention been built, made, run or tested? Yes_____ No__X__ Summary of the result:

Names of others known to have worked on this same technology inside of SAE, and other companies:

None to knowledge of inventors.

Date of any previous or planned disclosure external to SAE and type of disclosure (demonstration, paper given, presentation, published article, etc.). Please provide a copy of a paper or article, if applicable.

None. This is the first publication.

Was or will this disclosure be pursuant to a Confidential Nondisclosure Agreement? Yes_____ No__X__

Was any outside funding involved? Yes_____ No__X__ If so, describe:

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Submitter (Sign Legal Name)	Date	Submitter (Sign Legal Name)	Date
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Witnessed and Understood By (Type/Print and Sign)	Date	Witnessed and Understood By (Type/Print and Sign)	Date
/ SINDY YEUNG	REDACTED	/ Xiaofeng Zhang	REDACTED

NOTE: Each attached page of additional description must be signed, dated and witnessed. REDACTED

Identify any known related invention proposals, patents, publications or commercial work and attach copies, if practical.

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			REDACTED

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INVENTION PROPOSAL

Descriptive title of proposal:

A method for lowering flying height of magnetic head at low operating temperatures

Background

A magnetic head is used in a computer disk drive to write and read information on a magnetic disk. The write and read capability and capacity are controlled by the head disk spacing. Ideally, the head-disk spacing should stay unchanged at different temperatures. However, in reality, the flying height or head-disk spacing changes with environmental temperature. The reasons for the flying height change are the changes in head geometry such as crown and camber. At extreme low temperatures, for example, the flying height change can be up to a few nm due to head geometry change, leading to degraded recording performance or malfunction of the head.

To solve this problem, two methods have been used to compensate the flying height change at low temperatures. One method uses a local heating coil built in the head, which causes protrusion of the read-write area and therefore making the actual head-disk spacing unchanged. To the present authors' knowledge, this idea is being implemented in the actual drive. Since the heating coil is added to the head in the wafer level, this method adds complications to the overall process. An alternative method is to use a high current to the writer to heat up the pole area and protrude the area, leading to flying height adjustment. This method is also being evaluated in the computer disk drive. As can be seen that both techniques try to achieve protruding of the pole tip area. This may move to the minimum flying height point to the protruded pole-tip area, leaving it unprotected against possible contact from asperities on disk surface.

The present invention describes a new technique to adjust the flying height of magnetic head to solve the problem associated with disk drive operation at low temperatures.

The invention

A. The idea

The new method for adjusting flying height is shown in Fig. 1. The head-disk interface can be modeled as a quasi-parallel capacitor; the upper electrode is the magnetic head, and the lower electrode is the magnetic disk, and they are separated by a small air-gap. When a low voltage is applied to the head-disk interface, the flying height decreases with the applied voltage according to the following equation:

$$f = k v^2/d^2 \qquad (1)$$

Where f is the attractive force between two electrodes or head and disk, k a constant, v applied voltage, and d the head-disk spacing. It can be seen from equation (1), the d will decrease with increasing applied voltage as required by increased f at high voltages. In other words, the spacing between the head and disk can be decreased by applying a voltage.

To implement the idea on a disk drive, some changes on disk drives are required.

(a) First, an electrical wire for applying voltage to the magnetic head is required. This can be done through adding an electrical pad at the trailing end of slider in the wafer process.
(b) Second, the slider needs to be isolated from suspension that is usually grounded. This can be achieved by

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using an adhesive with high electrical resistance, so that there is no current leakage to the ground through suspension when a small voltage is applied to the slider.

(c) Third, it is desirable that a flying height monitor system is built into the disk drive electronics system to accurately control flying height for each individual head and to prevent possible head-disk contact while the flying height is being lowered. This can be achieved by using an electronic feedback system (shown in Fig. 1). The feedback system monitors the head-disk spacing by using read-back signal (i.e. amplitude or amplitude modulation as the intensity of these two parameters are closely related to the head-disk spacing), then controls the head-disk spacing by sending accurate voltages to the slider based on the measured head-disk spacing.

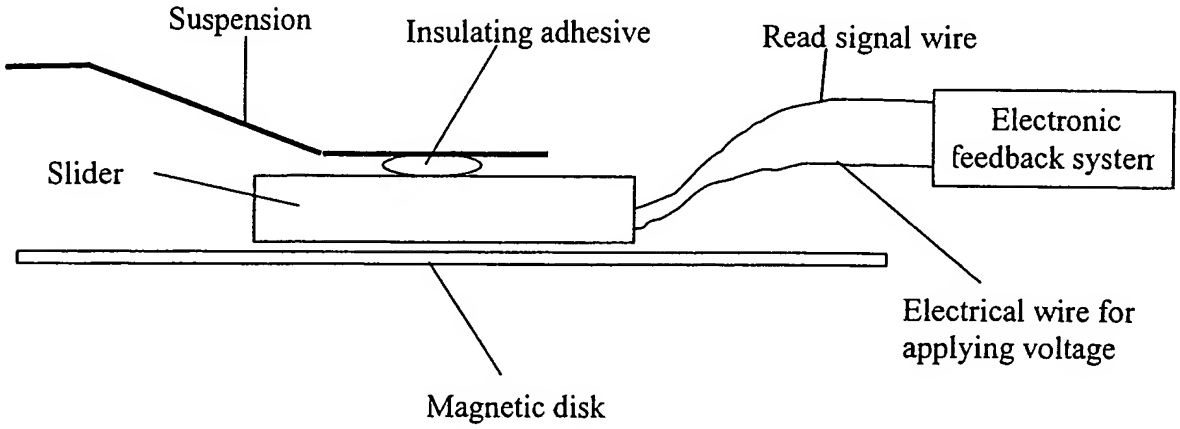

Fig. 1. A schematic diagram of the method for applying voltage to lower flying height at low temperatures

B. The demonstration

The head-disk spacing change with low voltages was measured on a Guzik tester. To accomplish this, the magnetic head needs to be isolated from ground so that low voltages can be applied to the head-disk interface. The electrical isolation of the head was achieved by using insulating shims on the HGA mounting point. The head-disk spacing change was measured by PW50 on Guzik, which stands for power width at 50% height of a read-back signal pulse, and it changes linearly with head-disk spacing. A DC power supply was used as the voltage source, and voltages -2 to +2 volts were used in the measurements.

Fig.2 shows a typical chart of Guzik measurements, where PW50 is plotted against applied voltage. As indicated in the plot, the flying height (PW50) decreases with applied voltage, no mater the voltage is positive or negative. This is expected from equation (1). As can be seen from Fig. 2 that for a voltage range of 0-2 volts, the PW50 change is about 0.12 uin or 0.06 uin/volt. So for a flying height increase of 0.06 uin, which is usually observed at cold operation conditions, 1 volt would be sufficient bring the flying height back to normal value.

One of main concerns with charge or voltage at the head-disk interface is the possible EDS damage of the GMR sensor. For the most GMR sensors used in the industry, the threshold is ~ 5 V. This is consistent with the observation that no ESD damage on GMR sensor was seen for voltages (up to 3 V) used in the experiments. It is therefore safe to say that applying low voltages (1 volt for lowering flying height) to the head-disk interface will

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unlikely cause ESD damage of the GMR sensor.

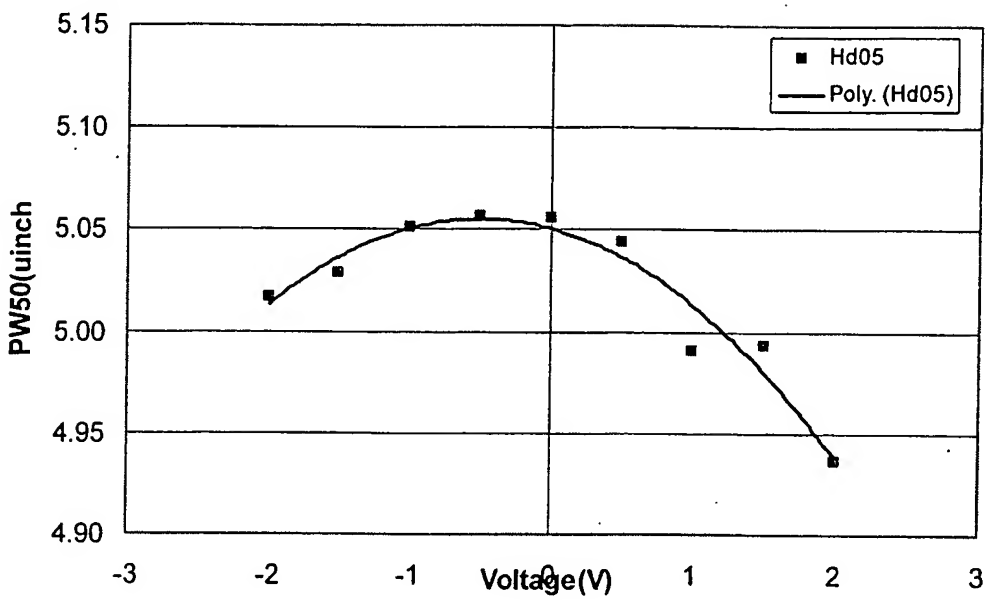

Fig. 2. A typical plot of flying height vs applied voltage

Advantages

1. **The present method provides an effective way for bring back the flying height to normal value for disk drive operating at low temperatures;**
2. **The present invention cause less tribology issues related to other techniques such as local heating, which may cause protrusion in one small area, leading to head-disk contact. Whereas in case of applying low voltage, the whole trailing edge is getting closer to magnetic media uniformly;**
3. **The present method involves simple changes on disk drive design for applying this technique;**
4. **The present invention requires only simple steps added to the magnetic heads process. The electrical pad for applying voltage can be easily added in the wafer process, and isolation between slider and suspension with insulating adhesives is the existing HGA process;**

Claims

1. **The method for applying a voltage at head-disk interface to lower the flying height at low operating temperatures;**
2. **The modifications on magnetic heads for applying low voltages**
   a. **Insulating the slider from suspension with non-conductive adhesives;**
   b. **Use a separate electrical pad on the magnetic head for applying voltage;**
3. **The disk drive modifications associated with applying low voltages to head-disk interface**
   a. **A feedback system for monitor head-disk contact by means of measuring the amplitude of read-back signals or the modulation of read-back signals;**
   b. **Method of adjusting voltage to an accurate value based on the information from 3a;**

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